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(54) **LAYING OF A CABLE WITHIN A DUCT**

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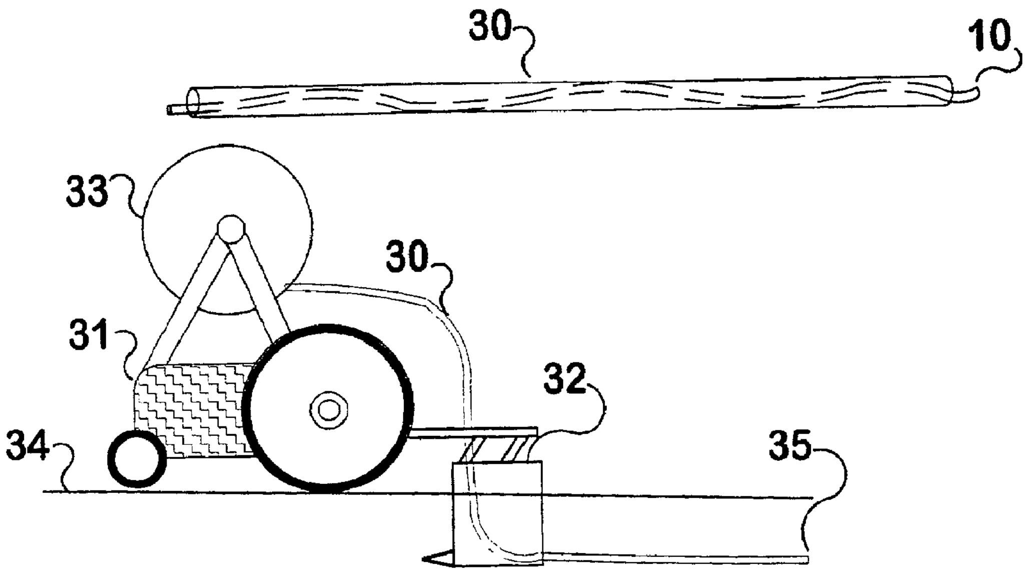
(57) **ABSTRACT**

For a cable to be laid inside a duct, the invention teaches the addition of "scales", projections, or roughening outwardly from the cable sheath to help a cable-laying procedure wherein the cable is carried through the duct, from all along its own length, by blown air emitted from behind. Substantial improvements in laying efficiency over existing blown air techniques, with less strain on the cable than if pulled by a winch, and reduced laying costs are claimed. Hence cables may be of lighter construction than that required for conventional laying procedures.



and for this purpose one further improvement may be to use a low-friction plastics material in at least the projections from the sheath (if not the entire sheath) so that friction is further reduced, (In **FIG. 2** the stick-on patches may be made from a plastics material with a reduced coefficient of friction such as PTFE sold as Teflon(R)).

EXAMPLE 1

[0029] (A Trial)

[0030] Our laying trial began with a relatively short trial length of cable, the sheath of which had been cut into with a knife along its length so that a series of spaced-apart "scales" each having a free end or tip pointing in substantially the same direction were created much as shown in **FIG. 1**—see **11** or **11**A.

[0031] We refer to these projections as "fish-scale projections", because any one projection resembles a lifted-up scale of a fish. There is a preferred direction of movement of the cable over the surface—away from the direction of the leading edge such that the scale tends to close with movement rather than be opened out. We use this modified cable in combination with the blown air method for pushing a cable along a duct. Our theory is that the projection is caught up by the flow of fluid (compressed air) from behind and hence the cable is pulled along the duct from a large number of points distributed along the entire length of the cable (or perhaps just the treated length, if only a "header" is so embellished with projections) of the cable, which substantially reduces stresses imposed on the cable and its contents during pulling over the prior-art "yank" technique (a pre-laid wire rope pulled along the sub-duct by a winch) or the use of a "parachute" with a compressed fluid.

[0032] The shape of each scale-type projection as constructed in this way is preferably such that it can engage with a flow of fluid from behind, assuming that our present theory concerning the basis of this invention is applicable. Possibly, sufficiently short projections can be used with a flow of fluid from either direction in order to cancel the minor objection that the cable can be laid in only one direction.

EXAMPLE 2

[0033] Each projection may be formed at a slight angle so that air movement along the side of the sheath of the cable becomes at least partially helical. In order to stop the cable from twisting, by acting like a driven fan, it may be useful to reverse the direction of the angle periodically. Formation at an angle is simple; for example either the cuts of **FIG. 1** are made at an angle (as indicated particularly with the projection **13**), or the stick-on projections of **FIG. 2**/example 5 are applied onto the sheath of the cable at an angle.

EXAMPLE 3

[0034] (A Manufactured Cable)

[0035] Each projection may be formed in some way during the process of cable manufacture, as for example when the sheathed cable emerges from an orifice of a sheath-applying stage of manufacture. At this point the sheath may be hot (or as yet incompletely cured) and softer, hence easier to embellish. (In contrast, the stick-on projections of **FIG. 2**/example 5 may be applied automatically at or about the time of laying the cable).

EXAMPLE 4

[0036] (A Manufactured Cable)

[0037] One construction method that is compatible with known cable manufacturing techniques is to wrap, in an open helical manner, a thick, rigid band around the cable. Preferably that band has a cyclically varying thickness or its outer surface may be constructed to resemble as far as possible the projections of **FIG. 1**. Optionally the direction or pitch is reversed periodically so that the cable does not tend to twist about its length.

EXAMPLE 5

[0038] (Applied Adhesive Projections)

[0039] Each projection may be formed by means of an externally applied material (see **FIG. 2**); for instance sticky plastics squares **21**, supplied on a tape **20** and rolled onto the exterior of a cable at spaced-apart positions about the radius, either late in manufacture, or at some subsequent time. The advantage of this approach is that the material of which the projections **22** are made may be different to that of the actual sheath, and that the integrity of the sheath is not compromised at all. (Knife cuts may pose a risk). For instance, the sheath itself may be an impervious, cheap, tough, rubbery, and nondegradable material, while the stick-on projections may be made of a low-friction and relatively inelastic material. Conveniently, the projections themselves lack adhesive (shown as a shading **23** in **FIG. 2**). The side view of one projection is at **24**.

EXAMPLE 6

[0040] (Applied Knife Cuts)

[0041] Each projection may be formed by a mechanical operation on the existing sheath of the cable at some time after manufacture, perhaps by an automated version of the knife cuts described with reference to example 1, or an embossing roller

EXAMPLE 7

[0042] (Method of Use)

[0043] A first method of laying a cable having added projections according to the invention is to treat it in a similar manner to cables blown into ducts as at present; however the "parachute" commonly used in cable laying (and believed by many to be indispensable) as a leading air catcher and dragging device may be dispensed with. Using the usual levels of air flow or lesser amounts, the modified cable is capable of advancing into and through the duct at a considerable rate.

[0044] Note that in the event of the sub-duct diameter being significantly larger than the cable diameter, it may at times be preferable to retain a parachute at the head in order that the leading end of the cable is held out straight or substantially so by the current of fluid. In the inventor's own experience so far this has not proven necessary.

EXAMPLE 8

[0045] (Method; Preloaded Sub-duct)

[0046] A second method of laying a cable having added projections according to the invention is to blow it into a

corresponding length of sub-duct while that sub-duct is still coiled on a dispenser such as a cable drum, prior to the sub-duct (or duct, as the case may be), being laid into a trench as cut by a mole plough **32** or the like. **FIG. 3** illustrates a short example length of sub-duct **30** containing a length of cable **10**. The cable is shown as having a sinusoidal arrangement, to provide for some slack to be taken up when the sub-duct is straightened out after laying by a mole plough **32** on the back of a tractor **31**. Possibly this operation can be done at a depot, or at a factory, but more conveniently it is a useful alternative that can be done in the field as an adjunct to conventional laying within already-buried sub-ducts. For example, if one cable emerging from a manhole or the like is to be taken away from the course of a prepared main trench, it would be possible to recover that cable from a figure-8 layout on the ground and blow it into a subduct held on a dispenser (drum) on a tractor fitted with a mole plough, and then send that tractor off to lay the combination up to a selected destination.

EXAMPLE 9

[0047] (Laying Method; Figure-8 Intermediate Steps)

[0048] It will be appreciated that this procedure for enhancing the laying of cables, such as fibre-optic telecommunications cables, renders more feasible the possibility of laying a quite long cable from a source to a destination without breaking and rejoining the cable. Rejoining is a tedious, expensive process that inevitably degrades the optical performance of a fibre-optic cable. Accordingly we provide a method (see **FIG. 4**) for handling the cable at intermediate way-points (generally manholes **40**, **41**) so that the full length of cable can emerge from a first length of sub-duct **30** (typically of the order of one kilometer) and subsequently be blown into a second length, and so on, until the entire cable is in place. Given that there may be a subsequent requirement to tap into the cable at any one manhole, there will preferably be a coiled length of cable (**46** in **FIG. 4** *c*) left within each manhole. As the free end **43** of the cable **10** emerges from an open end of a sub-duct (**FIG. 4***a*) it is transferred onto a surface (such as the ground) and is laid down in a figure-8 layout (**42** in **FIG. 4***a*) which has the particular advantages over simply rolling it up on a drum that (1) there is no imposed twisting effect and (2) by simply turning the mass of cable over (retaining the figure-8 shape perhaps by temporarily placing wraps about parts of the mass) the free end is ready to be picked up. After turning the "heap" of figure-8 configured cable over (**45** in **FIG. 4***b*) the free end **43** can be inserted **44** into the next portion of sub-duct or into a drum of sub-duct **33** intended for laying by mole plough, for the next stage of blowing. The direction of progress is indicated—as per **FIG. 1**—by the hatched broad arrow.

[0049] Variation 1

[0050] Each projection may have a shape slightly or even substantially unlike that of the fish-scale described within example 1. Variations on the shapes may be dictated more by an optimised method of manufacture, or of application, than on details such as aerodynamics, or frictional attributes.

[0051] Variation 2

[0052] Although our discussion of sub-ducts and the like has been in relation to laying in the ground, buildings, bridges, and the like may also be provided with equivalent paths for the laying of telecommunications cables. Indeed, fibre-optic devices are increasingly being used within a building as sensors for "smart structures" where for example the fibre itself is exposed over a defined portion to strain in a structure, and changes in optical properties of the fibre are used to sense movements of the structure. Cable and fibres to be used in this way are preferably laid out in a manner involving minimised likely or actual damage.

[0053] Variation 3

[0054] A telecommunications cable itself may now be optimised for a less stressful laying process, and be constructed with a lesser amount of longitudinal strengthening means, such as internal steel wires. Benefits may reside in reduced cost, reduced mass, and/or in increased space for data-carrying components such as more fibres.

[0055] Commercial Benefits of Advantages

[0056] The improved ability to lay fibre-optic cables according to this process translates into substantial savings by a number of avenues. Under the prior-art "pull" methods, the laying of a 10 kilometer length in an existing sub-duct in an existing trench involves: a $150,000 winch, a $50,000 compressor, a S80,000 jinker (cable drum supporter), 8 men, 2 trucks, a van, road cones and signs, and takes about 10 days to do the job. A manhole each kilometer is required (total 11) and at each manhole a cable jointing operation is required, which is technically complex and time-consuming. Each joint involves a loss of conductivity of light of about 3 dB, hence the light loss in any one fibre is a reduction of 512 times.

[0057] Under the present system, it may be possible to blow cable through the entire 10 kilometers in one pass. The winch, 6 men, up to 9 manholes, one truck, one van, and cable jointing equipment and time are no longer needed and the cable can be expected to reach the other end in less than half a day and in good condition; having been handled much more gently.

[0058] Alternatively, given that much of the mass of a cable is not optical fibre but supporting steel wires, tough sheathing and protective coatings, then it should be possible to downwardly optimise the required reinforcing structure—steel wires, bulk of plastics, and the like for this method of laying thereby producing cheaper, smaller, and lighter cables, more of which can be inserted into a given duct.

[0059] Although a number of preferred examples as described above have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions, and substitutions to the apparatus and methods described herein are possible without departing from the scope and spirit of the invention as set forth in the following claims.

1. An elongated cable adapted for being laid by blowing through a cable-carrying duct; the cable having a first or leading end, and having an outer sheath, the cable being capable of supporting an internal means for carriage of material or of data; characterised in that the profile of the surface of the outer sheath of the elongated cable is modified substantially along the length of the cable so as to form a plurality of surface projections protruding from the surface; the projections being capable of serving as bearing surfaces